

ACUTE DIFFUSE PURULENT MENINGITIS

OF AURAL ORIGIN.

(A General Survey of 103 Cases during a period of seventeen and a half years, from the Ear, Nose and Throat Department of the Royal Infirmary, Edinburgh, under the charge of Dr A. Logan Turner and Dr J. S. Fraser.)

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by

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DEFINITION.

Of the many definitions of this disease that of Holger Mygind¹ is the most satisfactory. He defines it from the clinical standpoint: "An acute febrile disease, caused directly or indirectly by an acute or chronic middle ear suppuration, exhibiting 'diffuse' brain symptoms and a cerebro-spinal fluid with pleocytosis, whether there are bacteria or not".

Before considering the clinical aspects of diffuse purulent meningitis of aural origin, it would be advantageous to investigate the chief anatomical points.

We are not so much concerned with the dura mater as with the pia mater and the arachnoid. The pia mater is everywhere closely adherent to the brain - there is no sub-pial space. It sinks into all the fissures, except in the cerebellum where it occupies only the larger ones. The pia mater is very vascular as the blood-vessels of the brain ramify in it. Each vessel is surrounded by perivascular lymphatics which, coming from the pia, penetrate the brain surface. "Leptomeningitis without a certain degree of encephalitis is not possible" (Panse²).

The arachnoid is a delicate membrane situated between the dura and pia but so intimately connected with the pia as to appear in many places one with it. The arachnoid, however, bridges across the sulci while the/

the pia sinks into them. Trabeculated tissue of a spongy nature connects them. Towards the base of the brain also there are tolerably large spaces between these two membranes, called cisterns. The trabeculae here are much finer and not so dense.

The Cerebro-spinal Fluid; its Origin, Circulation and Absorption.

Eagleton³ maintains that the conception that the cerebro-spinal fluid was secreted by the choroid plexus is probably false as the choroid plexus contains no real secreting elements whatever. The fluid presumably comes from the blood vessels, through the choroid plexus. The cerebro-spinal fluid circulates by the influence on the brain mass of the impact of the systolic and diastolic action of the heart, combined with the influence of respiration through the rise and fall of venous pressure. These changes in the brain's bulk cause an ebb and flow of the cerebro-spinal fluid system.

Starting in the lateral ventricles, the cerebro-spinal fluid flows through the foramina of Munro to reach the third ventricle: here its volume is augmented by the choroid plexus of that cavity and passes through the aqueduct of Sylvius into the fourth ventricle. The choroid plexus of the fourth ventricle furnishes a further contribution. The fluid/

fluid now passes out into the cisterna magna of the subarachnoid space through the minute foramina of Magendie and of Luschka, which perforate the lower part of the ventricular roof. From the cisterna magna the fluid permeates upwards and forwards round the sides of the medulla and over the cerebellar hemispheres. In order to reach the fore-brain it must pass through the narrow isthmus of the subarachnoid space which surrounds the mid-brain, and is bounded by the free edges of the tentorium cerebelli and the basiphennoid. The roomiest part of this passage is the cisterna interpeduncularis, from which the fluid ascends over the cerebral hemispheres. The fluid, after escaping from the ventricular system, through the foramina of Magendie and Luschka into the cisterna magna, may also pass caudally into the spinal theca - the most convenient anatomical site at which to obtain fluid for investigation. Absorption of cerebro-spinal fluid takes place almost entirely from the subarachnoid space overlying the cerebral hemispheres. The return to the blood stream of the fluid is the function of certain specialised structures derived from the arachnoid membranes - the arachnoid villi and the Pacchionian bodies which perforate the dura mater and project into the cranial sinuses and larger cerebral veins. Another and less important path of absorption exists in the perineural lymphatic spaces of the cranial nerves (Fraser and Dott⁴).

The principal nerves which are early affected are the oculo-motor, abducens and optic.

The oculo-motor nerve emerges from the oculo-motor sulcus on the medial side of the cerebral peduncle. As the nerve emerges from the brain it is invested with a sheath of pia mater and enclosed in a prolongation of the arachnoid. It runs forwards in the interval between the free and attached borders of the tentorium cerebelli in the cisterna interpeduncularis, then pierces the dura mater lateral to the posterior clinoid process. Thus it is seen that for a part of its course it lies free in the cisterna interpeduncularis and so is early affected by any change in the brain pressure.

The abducens nerve emerges from the brain at the lower border of the pons and the upper end of the pyramid of the medulla oblongata. It ascends upon clivus of sphenoid, anterior to the pons. It is thus contained in the cisterna pontis.

The intracranial portion of the optic nerve runs backwards from the optic foramen to the optic chiasma. It receives sheaths from the three brain membranes. These sheaths are separated from each other by spaces which communicate with the subdural and subarachnoid cavities.

PATHOLOGICAL ANATOMY.

Leptomeningitis is characterised by pus infiltration into the meshes of the subarachnoid space. The pus tends to spread along the larger pial vessels which course into the sulci and fissures of the brain so that the tops of the convolutions emerge from the exudate. The surface of the brain immediately underneath the pia mater becomes oedematous. The convolutions are generally flattened and the pial vessels congested. The cerebral tissue presents softening and, in long-standing cases, superficial abscesses. Discolouration of the brain surface is occasionally seen. If the infection originates in the posterior fossa the meningitis tends to be confined, for a time at any rate, in this locality - no doubt due to the anatomical features of the tentorium cerebelli and the narrow passage from the posterior fossa to the cerebral fossa. Should the infection be through the labyrinth and the elements of the nerves in the internal auditory meatus, it spreads directly into the cisterna pontis and hence a generalized meningitis is rapid. If, on the other hand, the infection comes from, e.g., a subdural abscess, it passes into the enmeshed subarachnoid space, where the spread is comparatively slow and the meningitis is localised until one of the cisterns becomes involved.

When/

When the infection originates in the temporal lobe, the spread is into the lateral ventricle in the vast majority of cases. The infection follows the course of all the ventricles, being rapidly carried by the cerebro-spinal fluid, and pours out in the first case (as already referred to under the course of the cerebro-spinal fluid) round the base of the brain. The following is an extract from the post mortem notes of a case of temporal lobe abscess: "On removing the brain, the base, pons, and medulla were found to be covered with a foul suppurative exudate. There was extensive general congestion of the meninges. On incising the brain a large abscess cavity was found in the white matter at the site of the optic radiations on the right side. This had ruptured into the lateral ventricle and spread forward into the anterior horn and to the left ventricle". It must not be forgotten in this connection (temporal lobe infection) that the spread may also take place in an upward direction. In one particular case, where the abscess in the temporal lobe was very large and the entrance to the abscess cavity was very "mushed up", the post mortem report was as follows: "The pia arachnoid in the sulci of the parietal lobe and posterior part of the frontal lobe contained pus, this being particularly marked in the upper part of the fissure of Sylvius".

In blood-borne infection the pus infiltration is mostly/

mostly confined to the vertex of the brain.

We have thus seen that the principal routes of infection come from:-

- (1) Direct extension through contact of necrotic bone with the dura.
- (2) Through the labyrinth by the nerve elements in the internal auditory meatus, the aqueductus vestibuli or the aqueductus cochleae.
- (3) Through some intermediary focus of infection, e.g., brain abscess, sinus thrombosis.
- (4) By way of the vessels communicating between the middle ear and the dura mater, through the petro-squamosal suture or its remains.

SYMPTOMS and SIGNS.

The symptoms which make up the clinical picture of meningitis are due to intracranial pressure, the presence of waste nitrogenous products (tissue destruction) in the cerebro-spinal fluid and the toxins generated by the bacteria. The last two produce the intoxication symptoms. Before discussing the symptoms it would be illuminating to turn for a moment to the experimental work of Kopetzky⁶ in this connection.

Kopetzky notes that under compression of the brain the obstruction begins on the venous side and extends backwards towards the arterial side. The compression force being constantly increased, the veins are pressed empty; very soon afterwards, the capillaries/

capillaries and the smaller arterioles are, in their turn, emptied. This produces a condition of anaemia and occurs exactly at the moment when the degree of compression exceeds the degree of blood pressure. This anaemia stimulates the vaso-motor centre which responds by driving up the degree of blood pressure above the level to which the compression-pressure has been put. The blood pressure curve rises above the compression curve and the medulla, receiving a fresh blood supply, responds in a relaxation of the vaso-motor centre and the blood pressure again gradually drops beneath the level of the compression-force, which again stimulates the vaso-motor centre, and so on. Shortly before the compression force reaches the level of the blood pressure, respirations become slower and more shallow. When the intracranial pressure exceeds the blood pressure the respirations stop. When the blood pressure rises above the intracranial pressure the respirations reappear. Death is due to vaso-motor paralysis. When the vaso-motor centre becomes paralysed it is unable to raise the blood pressure any more, therefore respirations stop.

Kopetzky also assumes that the normal metabolism of the cells of the central nervous system results in throwing into the cerebro-spinal fluid stream minimal traces of lecithin decomposition products, namely, cholin/

cholin. The cerebro-spinal fluid carries these into the blood, where further decomposition ensues. Under the influence of bacterial poisons, the cerebral anaemia, the oedema of the tissues, with its accompanying acidity, the interference with the free circulation of the cerebro-spinal fluid, an accumulation of these poisonous basic products takes place and they exert their deleterious activity on the nervous tissues directly, still further damaging them. The result of all this is seen in the evidence of toxicity as shown in the clinical picture.

The advent of a meningitis is generally ushered in by a feeling of malaise and shivering.

General Aspect.— The patient is frightened and anxious and seems full of forebodings as to his impending fate. In children this fear is demonstrated by the "meningitic cry", mostly heard as they waken from sleep. The patient generally lies curled up on the side of the lesion. He looks overwhelmed with toxæmia.

The principal subjective symptom in the present series of cases was headache, which varied in severity and intensity. In one particular case the patient's headache was so severe that he banged his head against the walls of his bedroom for relief. In other cases the patients became demented and shouted out in their agony. Children may tear at their hair. This distressing/

distressing symptom may always be relieved by lumbar puncture, i.e., relieving the intracranial pressure. In cases treated by continuous drainage (labyrinthine drainage) this symptom remained in abeyance so long as the drainage held good. The headache is usually referred to the frontal region, extending over that side of the head in which the primary lesion is situated, or it may be located on both sides of the occipital region. It is generally constant and uninterrupted. Headache is a very early sign.

Drowsiness was noted in many cases before the typical symptoms appeared, but this was not peculiar only to the labyrinthine cases. "The first sign of a meningitis in a case of labyrinthitis is slight torpidity without irritability" (Jenkins⁷). This was confirmed in an early case of the present series.

Giddiness, nausea and vomiting are frequent.

Other symptoms are: restlessness and excitement; noisy or muttering delirium, from which the patient may be roused for a moment though he does not answer questions intelligently; flocculation appears as a terminal phase and is of grave import; photophobia and supersensitiveness to sound; clonic and tonic convulsions resembling epileptiform cramps. The patient is generally irritable, utterly unreasonable and resents any interference. The tongue is furred and dry. The teeth in more advanced cases are covered with sordes and the breath is foul. Thirst is/

is generally complained of. The patients become rapidly emaciated: this is very marked. Obstinate constipation is present throughout the course of the illness. The urine is scanty, as is common in all febrile conditions. If the fourth ventricle is specially affected, then glycosuria may be present. When the lumbar region becomes affected the reflexes are abolished and incontinence of urine and faeces also results. Pain may be present over the sacrum and anus.

In four cases of the present series herpes labialis was present: in two of these cases the meningitis was secondary to sinus thrombosis. Dermography (vaso-motor irritation) was noted in some of the cases as was also blueness of the extremities. In one case of meningitis following temporal lobe abscess the patient developed blisters about the size of a florin, principally situated around the pelvis. Later the blisters rapidly became black, sloughy and almost gangrenous (cultures showed the same organisms as those present in the blood and cerebro-spinal fluid). In some cases there is hyperaesthesia of the skin, i.e., a touch on the calf or sole of the foot produces pain.

The fever varies according to the nature of the case. It is always present and is of the hectic variety. Frequently just before death there is a continuous rise till, in some of the cases, the temperature reaches 107°F . Generally speaking, in the/

the cases which recovered, the temperature did not remain continuously high during the course of the illness. The fever may be ushered in with a rigor, and rigors during the illness have been noted.

The pulse at the beginning of the illness is generally slowed owing to irritation of the vagus (this was fairly constant) but, as the disease progresses, the pulse rate increases so that at the terminal phase it is racing and irregular (this is due to paralysis of the vagus). The pulse, then, shows no correlation to the temperature.

The respirations may be slow but in the present series of cases the respirations were unaffected from the normal. When unconsciousness supervenes, Cheyne-Stokes breathing, typical and atypical, is present.

After a careful study of the case records of patients who recovered and of patients who died, I have found no relationship between the pulse rate, the temperature and respiration curves and therefore they are useless on the point of prognosis.

Neck rigidity due to spastic condition of the muscles is common in all posterior fossa infections. Stiff neck is present when it is not possible actively or passively to bring the head so far forward that the chin touches the chest. On attempting to flex the rigid neck there is extreme pain and the knees are automatically bent. A slight degree of stiff neck is found/

found in early cases. Körner⁸ noticed, in exclusive disease of the cerebrum, absence of neck rigidity during the whole duration of the illness.

Pain on pressing the membrana atlanta occipitalis is found at an early stage. Later on, pain on tapping over the cervical vertebrae is invariably present.

The abdomen becomes contracted and boat-shaped owing to spasticity of its muscles. The superficial reflexes disappear, first on the side of the lesion and then on the other side.

An indirect test of the sensitiveness to pain of the meninges is presented by Mendel's auricle symptom which is based thus:⁹ The dura mater is supplied by the meningeal branch of the vagus which springs from the jugular ganglion. An irritation of the dura mater meets the fibres of the jugular ganglion and from there radiates the auricular branch of the vagus which supplies the skin of the posterior wall of the external auditory meatus. Mendel tested the hyperaesthesia of the posterior wall of the external auditory meatus with a probe and states that he always observed violent pain in all meningitic cases. This auricular symptom is present at an early stage but requires a healthy meatus.

An early symptom, according to Knick,¹⁰ is retro-mandibular pain on pressure (this must not be confused/

confused with glandular disease).

Kernig's sign is one of the most sure and diagnostic. The test need not be enumerated. It is almost peculiar to meningitis, being absent in other endocranial diseases. It is due to a spastic condition and is found at an early stage.

The knee jerks are at first exaggerated and then are absent. Babinski's reflex is present (sudden extension of the great toe produced by scratching the sole of the foot).

Paralysis of various cranial nerves is seen, especially of those nerves clothed by brain membrane sheaths. The principal nerves affected are the optic, the oculo-motor and the abducens. The optic nerve is early affected. In the primary stages the veins of the fundus become tortuous and slight oedema of the papilla is present. Later the prolonged compression gives the typical "choked disc" of optic neuritis. Irritation of the oculo-motor nerve gives contraction of the pupils and thus in the early stages of meningitis the pupils are contracted and react sluggishly to light. Later, as paralysis supervenes, the pupils become dilated and fixed. The pupils in some of the present cases were equal and in others unequal. Diplopia was present in a few cases. Ptosis and loss of power of accommodation, also slight protrusion of the eyeball, owing to relaxation of its muscle, may be seen.

Hippus/

Hippus is occasionally noted. (This is a condition in which the pupil contracts to light but immediately dilates again and continues to change in size.)

Nystagmus, perhaps more commonly seen on the affected side but in no wise always so, is a variable symptom.

Along with the above signs, convergent/squint was not infrequently noted, showing involvement of the abducens nerve. The trochlear nerve may be irritated and then paralysis is present, the patient being unable to turn his eye downwards and outwards.

Blood: leucocytes, generally over 15,000; polymorphonuclears show increase; eosinophiles are decreased; the fibrin is increased. There is a progressive increase in blood pressure.

Changes in Cerebro-spinal Fluid. According to Eagleton¹¹ "contrary to the generally accepted view, there is no increase of the intracranial pressure in the early stages of meningitis because no matter how excessive the production of fluid may be, in nature's attempt to limit or eradicate the bacterial irritant excess this/fluid is immediately removed by absorption into the blood vessels".

Lumbar puncture was first performed by Quinke in 1891. In the early stages of meningitis the fluid obtained/

obtained by lumbar puncture is obviously no indication of what is going on in a locality so remote from the brain. The fluid obtained then is generally clear, under pressure and with an increase of cells per cubic millimetre. Later, as the disease progresses, the fluid becomes turbid from the presence of pus cells, and at this stage, taken in conjunction with the clinical signs, it is safe to diagnose diffuse purulent meningitis.

The question of the diagnosis of acute diffuse purulent meningitis is in a very unsatisfactory and mixed state. Some authorities insist on the presence of micro-organisms in the cerebro-spinal fluid.

In the present survey of cases the sample obtained by lumbar puncture was in some cases sterile, while at the post mortem examination undoubted and extensive meningitis was present. Also the fluid in the lumbar region is constantly changing - while at one time it is sterile, the next time it contains micro-organisms, therefore it is a matter of chance what you obtain. Holger Mygind¹² points out "that in 70 per cent. of his cases leading to death from uncomplicated meningitis, the cerebro-spinal fluid obtained by lumbar puncture was sterile although in all these cases bacteria were found post mortem when searched for- The conclusion must therefore be that the presence of bacteria is not an absolutely necessary finding in true meningitis". In 16 per cent. of the present cases, ending fatally, the fluid was sterile.

Physical Characteristics of the Cerebro-spinal Fluid. The fluid is increased in pressure. The freezing point is lowered.

Chemical Properties of the Cerebro-spinal Fluid.
Non-reduction of Fehling's solution.

The result of pathogenic bacterial growth in the fluid is manifested by the early disappearance of the carbohydrate element except in very severe cases where the outcome is rapidly fatal, then the sugar is increased. Some authorities diagnose meningitis by this fact, coupled with the increased pressure of the fluid.

Reaction of the Cerebro-spinal Fluid. Normally it is alkaline and in the early stages of meningitis it possesses a low degree of alkalinity. It later becomes acid in reaction. There is an excess of globulin. Lactic acid is present. Albumin is largely increased: normally albumin is present only in a very small quantity. The increase is due to tissue destruction and an out-pouring from the blood; above 0.5 per cent. is pathogenic. The presence of polynucleose is noted at an early stage.

Greenfield¹³ states that the only tests which give any indication as to whether or not the meningitis is generalized is the chloride percentage. The percentage is greatly decreased whereⁿ general meningitis is present and, as long as the percentage is normal, the meningitis should be circumscribed.

"From what we know of the cerebro-spinal fluid, a fall in the chlorides is due to a breaking down of the barrier which separates blood and cerebro-spinal fluid for, in health, the chlorides in the cerebro-spinal fluid are always higher than in the blood, but when the barrier between the two fluids is reduced, their chloride percentages tend to approach one another".

Cell Content of the Cerebro-spinal Fluid. When more than eight cells to the cubic millimetre are present, it is significant of some pathological change in the meninges. (In eight cells I have struck an average of different opinions.) In a turbid fluid the cell content is round about 300-1100 to the cubic millimetre.

Lastly, there is the Bacteriological examination to be made. Generally, in the present cases, the micro-organism isolated was of the streptococcal type. The organism isolated from the swab taken from the primary focus, in the great majority of cases, coincided with that found in the cerebro-spinal fluid.

TYPES OF INFECTION.

We must divide the cases into (1) fulminating and (2) comparatively mild infection.

In the fulminating type, micro-organisms, generally streptococci, are seen in great numbers in the film preparations and grow readily on culture media. When a case presents these characteristics then the case will most certainly prove fatal.

The recoveries are not of the above type but I think represent a milder infection. Their spinal fluid all contained pus cells. In two of the cases, streptococci were demonstrated in film preparations. Of these two cases, no organisms were cultured on ordinary media in one, but when the ordinary media was heavily inoculated a pure growth of streptococci was obtained and in the other case a very scanty growth of streptococci was obtained on ordinary media. This may demonstrate the feebleness of the organisms. On the other hand very virulent organisms are difficult to culture but with such a type of infection I am inclined to think that the meningitis so produced would fall into the category of fulminating meningitis, which is invariably fatal. The remaining nine cases were sterile (five of these cases grew organisms on culture, such as staphylococci, sarcinae, an organism resembling *B. ozoenae* and *B. of rhino-scleroma*, Gram negative bacillus, all of which were very probably in the/

the nature of a contamination).

The cases with sterile turbid cerebro-spinal fluid which ended fatally and came to post mortem examination all showed a definite and well-marked meningitis (organisms were demonstrated in the subarachnoid exudate in the cases which were examined for organisms). Is this then due to a few highly virulent organisms settling down in one spot and exerting their power from there?

From the above figures what do we conclude? First and foremost that a case presenting a cerebro-spinal fluid which is sterile has a definitely better prognosis than that of a case teeming with organisms which culture readily on ordinary media; but we must not forget that a case with sterile cerebro-spinal fluid may end as surely fatal as that with a fluid crowded with organisms. A case teeming with organisms must of necessity be overwhelmed by sheer force of numbers, whereas when the infection is limited the body can concentrate its forces on that spot and so set up a more stout resistance.

Taking all the cases as a whole, in the cerebro-spinal fluid obtained streptococci were present in 41 of them, pneumococci in 17, *B. proteus* in 5, while 17 of the cases were sterile.

LOCAL CONDITIONS.

Earache is very common and is generally the first symptom complained of. It is present before any meningitic symptoms develop. Earache in a case of chronic suppurative otitis media is always of grave import and requires careful examination and elimination.

Discharge was almost always present at some time but it was noticed that in not a few cases the earache commenced when the discharge dried up.

The tympanic membrane was of course comparable to whether the middle ear suppuration was acute or chronic.

Cholesteatoma was present in many but by no means all of the chronic cases.

Complete deafness is present in labyrinthine cases. Delayed deafness may occur from intracranial pressure on the stem of the auditory nerve.

Pain may be present on tapping over the temporal or occipital region of the skull.

These symptoms are common to many aural diseases but, taken in conjunction with the general manifestations, are of value in diagnosis.

DIAGNOSIS.

In early cases the diagnosis is difficult and uncertain: in advanced cases it is easy. It must be kept in mind that meningitis is always a possible complication of otitis media and it should never be lost sight of, especially when the otitis is already complicated by brain abscess, labyrinthitis, sinus thrombosis, etc. (In a case of temporal lobe abscess, after operation the temperature remained fairly stationary at normal. The case was thought to be doing well and making good progress when suddenly the temperature shot up to 102°F. and all the signs and symptoms of a fully developed meningitis were present. Post mortem examination showed rupture of the abscess into the ventricles.)

Recently Jervell¹⁴ has initiated a test which depends upon the permeability of the meninges whereby the presence or absence of meningitis may be decided. The normal meninges and plexus choroides have the power of preventing a number of substances that are foreign to the organism from passing into the spinal fluid: diseased meninges have lost this power. This permeability of the meninges to chemical substances is greatly increased in meningitis. Jervell gives two grammes of uranin, made up in wafers, to an adult per mouth. One or two hours afterwards, the patient turns yellow and this disappears in five to six hours.

Three/

Three hours after the dose a lumbar puncture is made. In meningitis the fluid gives off a distinct greenish fluorescence (presence of blood may confuse it). In circumscribed meningitis the uranin does not enter the fluid or does so in relatively small quantities. This test is very useful in early cases. It may, however, be misleading as to the extent of the meningitis. In one case of suspected abscess of the temporal lobe, in which I made use of the test, the drug was administered as recommended. The dose of two grammes of uranin was given between two wafers but the patient experienced difficulty in swallowing this, therefore repeated small doses up to two grammes would seem to be better borne. The patient turned yellow in quite a short time. At the operation a large temporal lobe abscess was found, with the dura adherent to the brain at the site of the abscess: the condition of affairs being a localised meningitis, a lumbar puncture was performed. The cerebro-spinal fluid was clear, under tension and definitely opalescent. This operation was performed three weeks ago. The patient is still having her brain abscess drained but there are no signs, up to the present, of a general meningitis. Too much stress, therefore, must not be laid on this test.

Lately I have had an opportunity of examining a very early case of meningitis of labyrinthine origin which is illustrative in the matter of early diagnosis.

M.S., male, aged 32. The patient was mentally clear on admission but his wife stated that he had been slightly drowsy all day - there was no drowsiness apparent to us (vide Jenkins). The patient complained of headache and stated that he had had intense earache the previous night, keeping him from sleep, accompanied by vomiting and giddiness. The temperature was raised to 99.4°F. , pulse 70. On examination the external auditory meatus on the affected side was full of foul-smelling pus. The patient was absolutely deaf in the affected ear. On Romberg's test he fell to the affected side. Spontaneous nystagmus to both sides was present but was most marked to the unaffected side. Kernig's sign was definite: knee jerks slightly exaggerated: Babinski's sign present. There was just a little stiffness when the patient bent his chin towards his chest and he was unable to touch his chest with his chin: the pain produced on attempting this was referred to the dorsal region. Lumbar puncture was performed: the fluid was under great pressure and contained a multitude of pus cells. Unfortunately, when the needle was about to be withdrawn, the fluid became blood-stained. Later lumbar punctures have all obtained fluid coloured with a little blood admixture due, evidently, to bleeding into the canal.

In conclusion, the diagnosis rests on general symptoms, the chief being headache and Kernig's sign, the/

the findings in the lumbar puncture fluid - pressure, increase of cells per c.m.m., inability to reduce Fehling's solution and presence of pus cells (micro-organisms not essential).

Diffuse purulent meningitis must be differential diagnosed from tubercular meningitis, but here the cerebro-spinal fluid is quite clear and lymphocytes predominate and the blood count seldom yields a leucocytosis approaching 15,000. It is distinguished from epidemic cerebro-spinal fever by the demonstration of the meningococcus in the spinal fluid.

The various degrees of meningitis are confusing. In meningismus the signs and symptoms are identical with a purulent meningitis but the cerebro-spinal fluid is normal. Serous meningitis is a preliminary form of septic meningitis but here the spinal fluid is under pressure and clear and the lymphocytes are increased. In sympathetic meningitis (Plant and Schotmüller¹⁴) the spinal fluid is usually ^{under} increased pressure with an increased cell count, ranging from 250 to 3,000 cells, chiefly polymorphonuclears; the globulin reaction is marked and bacteria are absent.

In comatose cases examine the urine for diabetes or uraemia. In all other cases of meningitis during, e.g., pneumonia, exclude an ear condition and the diagnosis is obvious.

PROGNOSIS.

Diffuse purulent leptomeningitis is a very fatal disease. Out of the 103 cases of the present series, eleven recovered, or roughly 11 per cent.

For prognostic considerations we shall take Alexander's¹⁶ classification of suppurative meningitis on an anatomical aetiological basis:-

1. Meningitis with uncomplicated acute suppurative otitis media 24
2. Meningitis with uncomplicated chronic suppurative otitis media 25
3. Meningitis complicated by otitic brain abscess (temporal lobe abscess 21, cerebellar abscess 7). 28
4. Meningitis complicated by sinus thrombosis and extradural abscess 21
5. Meningitis complicated by labyrinthine suppuration. 5

More than half the cases (59) occurred between the ages of 6 and 25: only two cases were recorded below five years (both ended fatally).

The figures with regard to age incidence are as follows:- 0 - 5 years, 2: 6 - 10 years, 15: 11 - 15 years, 16: 16 - 20 years, 15: 21 - 25 years, 13: 26 - 30 years, 7: 31 - 35 years, 10: 36 - 40 years, 7: 41 - 45 years, none: 46 - 50 years, 3: 51 - 55 years, 3: 56 - 60 years, 4. We thus see that diffuse purulent meningitis is a disease of comparatively early life. The eleven patients who recovered were between the/

the ages of 9 and 32 years, eight of them being between 12 and 21 years. Seven of the eleven were females. In nine of the eleven the right side was affected.

The disease is more common in males, the figures being 75 males to 28 females, almost three to one. The disease originated on the right side in 59 cases and on the left side in 44 cases.

Of the 103 cases, meningitis complicated chronic suppurative otitis media in 68 and acute suppurative otitis media in 35: thus chronic middle-ear suppuration is more prone to meningitis. Under the age of 25 the acute cases numbered 18 and the chronic cases 42: above the age of 25, the chronic cases numbered 21 and the acute 12, so that as age advances the proportion of acute cases rises.

These statistics tally with those of Körner. In the young and the middle aged the issue cannot be very much in doubt.

The recoveries included four cases of temporal lobe abscess, one case of labyrinthitis, four cases of sinus thrombosis and perisinus abscess and two cases of uncomplicated acute suppurative otitis media.

The fulminating type of meningitis is always fatal. Its course is practically uninfluenced by any measures, operative or otherwise.

Alexander's classification has a disadvantage, as in some of the cases two complications were found together/

together, e.g., temporo-sphenoidal lobe abscess and labyrinthitis. This difficulty has been overcome in the present thesis by only putting down in the table the lesion which has obviously caused the meningitis.

TREATMENT.

General Measures. Keep up the patient's strength by treating the fever with antipyretics, frequent sponging of the whole body with tepid water, allaying the headache by the application of an ice-bag to the head. Hygiene of the mouth is important and materially adds to the comfort of the patient. The diet should be light, nourishing and fairly rich in carbohydrates, the meals small in amount and frequent. The bowels should be kept well open with calomel or enemata as constipation is very obstinate. The skin may be stimulated by rubbing with a hard towel after the sponging. The patient should be encouraged to drink as much water as possible.

Chemical Therapy. Morphia and heroin are contra-indicated. Death ensues from paralysis of the respiratory centre and in one case in the present series the end was precipitated by the administration of morphia. Alcohol should be avoided. Urotropine may be tried in doses varying from $\frac{1}{2}$ to 8 grammes thrice/

thrice daily till symptoms of intolerance (haematuria, burning in the bladder, strangury) occur.

Trypaflavine may be administered intravenously, 50 c.c. of a two per cent. solution (equal to one gramme of trypaflavine).

Methylene blue, subcutaneously and collargyrol and eusol intravenously have been used.

On account of the fact that the permeability of the plexus filter for antibodies is heightened by preceding doses of morphia (Lemaire and Debre¹⁷) some treat their cases by small doses of morphia.

Oxygen may be given for embarrassed respiration.

Vaccine therapy is sometimes useful. If the infecting organism is a streptococcus, anti-streptococcal serum, preferably autogenous, is given intramuscularly in doses of 50 c.c., three doses in all at eight hour intervals. About 20 c.c. of the serum may be given intrathecally (it probably acts better intravenously) after a corresponding amount of fluid has been run off.

Lumbar puncture is useful in so much that it relieves the pressure and thus alleviates the symptoms due to that cause. It cannot eradicate the disease but manifestly aids the tissues in their fight and thus creates more favourable conditions.

Flieschmann¹⁸ regards the beneficial effect of lumbar puncture thus: The temporary decrease of brain pressure brings about a regulatory amelioration of/

of the nutritive values (which have been prostrated by brain pressure) in vital endocranial tissue centres, and gives the defluction canals, which are also impeded in their function by brain pressure, the possibility of fulfilling the demands for the interchange of fluids (secretion and resorption).

By the flow of the liquor and consequent greater liquor and exudate resorption a greater secretion and exudation of liquor containing leucocytes is formed and therefore bactericidal. By the resorption of pathological liquors, excitors and toxins enter the blood and stimulate formation of antibodies which enter the liquor because of the porousness of the plexuses caused by inflammatory injuries.

Experiments show "that involvement of the meninges from the blood stream was facilitated, after removal of cerebro-spinal fluid, by the reduction of the pressure of the fluid, even if such reduction was of very short duration. If a septicaemia is produced in animals by the intravenous inoculation of a pathogenic organism, a fatal meningitis is established by lumbar puncture. Meningitis did not occur in those animals in which cerebro-spinal fluid was not withdrawn" (Davis¹⁹).

Dangers of Lumbar puncture.- Only a very small amount of cerebro-spinal fluid should be withdrawn for diagnostic purposes. The procedure may cause displacements or loosening of adhesions surrounding pus in/

in a case of circumscribed meningitis, thus converting it into a general meningitis. Sudden death may result from removing too much fluid, which causes a sinking of the brain into the foramen magnum and thus compressing the medulla oblongata, with all its important vital centres. Fluid should not be sucked out of the canal in cases of meningitis for above reason. Minor symptoms of headache, air hunger and faintness will not be considered here. The patient should always be in a recumbent position when lumbar puncture is performed.

Radical Treatment. The primary focus of infection should obviously be dealt with first of all. In acute cases of middle ear suppuration with mastoiditis and no other lesion, apart from the meningitis, many authorities recommend free removal of diseased bone and also a moderate amount of the contiguous healthy bone. Cases of recovery following this procedure have been recorded by Brieger, Hinsberg, Kerrison and others²⁰.

In one case of the present series, when meningitis followed sinus thrombosis, the free exposure and removal of the infected thrombus was sufficient, along with frequent lumbar punctures, to clear up the meningitis. With the appearance of a cerebellar abscess the meningitis returned, but when the abscess was opened and drained the meningitis again/

again cleared up, this time finally.

More commonly small incisions are made in the dura extending down to the subarachnoid space, in order to drain the cerebro-spinal fluid. Hernia of the brain matter may occur through the dural incisions.

If the meningitis should ensue from a labyrinthitis, then the intralabyrinthine drainage, first introduced by West and Scott, is eminently the line of treatment. Roughly the details are as follows.- The radical mastoid operation is first performed. The bone is removed from over the sinus and then the dura mater separated towards the internal meatus. The bone overlying the undermined area is next removed and during this procedure the dura is generally guarded by a Stacke's protector. Neumann's labyrinth operation is now performed, the lateral and posterior semicircular canals being opened up, the promontory removed and the cochlea opened up, thus giving access to the internal auditory meatus. The internal auditory meatus is an ideal natural drainage tube whose walls must always remain patent, also the subarachnoid space is patent to the fundus. A silver wire may be introduced into the internal auditory meatus as a drain.

Maloens²¹ has recently treated his cases by operation (removal of diseased tissue and incision of the dura) and by the following post-operative treatment/

treatment:- He employs septicémine, a drug composed of urotropine and iodine in combination, intravenously. The first time he used it, he administered it intrathecally but abandoned this route because a substance injected into the lumbar portion of the spinal canal diffuses towards the brain very badly. This slow diffusion is well seen in spinal anaesthesia. He now gives the drug intravenously, the dosage being at first two ampoules of 4 c.m. each, after lumbar puncture has been performed. The operation cavity is also swabbed out with septicémine. Maloens records very favourable results from its use and attributes to it a recovery. He assumes that the iodine molecule of the drug, besides being antiseptic, speeds up the endocrine organs and the thyroid in particular, promotes intra-organic oxidation and increases the leucocytes. At the present moment a case is being treated post-operatively with this drug, in the Ear and Throat Department of the Royal Infirmary, Edinburgh, and the results are very encouraging as the case is well on the way to recovery but, as no extensive trial has as yet been given to it, one cannot yet prognosticate.

A line of treatment carried out by Eagleton²² but not performed on any of the present series of cases is as follows:- The infected veins and cisterna are placed at rest by ligation of the common carotid. The internal carotid and its terminal branches pass directly/

directly through the basal cisterna and its constant pulsations must contribute to the extension of the septic process in this region. Ligation of the common carotid in three instances has had the effect of reducing the ocular tension of both eyes, for a considerable period after its performance. This being so and as there is known to exist a definite relationship between the cerebro-spinal fluid and the ocular tension, it is fair to assume that ligation of this internal carotid lowers the intracranial pressure as well.

Another method of attack is drainage of the cisterna magna: for this operation we are indebted to Haynes²³. He performs the operation for the object of relieving intracranial pressure and restoring blood to the vital centres. The arachnoid in this region is closely applied to the dura mater, so leaving quite a wide gap between it and the pia mater. This route affords an inspection of the foramen of Magendie. Briefly the steps of the operation are laid down by Haynes as follows:-

Incision in the middle line from the occipital protuberance to the spinous process of the axis, and carried down to the occipital bone and posterior arch of the atlas. The periosteum is stripped from the occipital bone, taking with it the inner portion of the origin of the attached muscles, and the occipital bone is bared for about a distance of one and a half inches/

inches vertically and one inch transversely, at the foramen magnum. A self retainer is now introduced. The trephine is applied to the middle line about one inch from the margin of the foramen magnum and the bone is removed. The dura is detached from the bone in advance. The dura mater now presents. The occipital sinus will be seen showing a blue colour through the dura, which is divided cautiously in case the arachnoid is adherent to it. The arachnoid is now slowly incised and the condition in the cerebello-pontine angle is investigated. A small wick of gauze is placed within the margins of the dura and arachnoid and left protruding from the wound. There is no danger of a hernia cerebelli. This operation was carried out in one of the fatal cases in the present series. It certainly keeps the distressing symptoms in abeyance.

The remaining methods of treatment are suboccipital puncture, ventricle puncture and lavage of the cisterns.

Suboccipital puncture is performed with the patient lying down with the head tilted towards the chest. A lumbar puncture needle pierces the skin at the level of the second cervical vertebra and, holding it absolutely in the middle line, it is pushed forward in the direction of the occiput and so through the atlanto-occipital membrane. This operation requires to be done by skilled hands as the field/

field of operation is in the vicinity of the medulla oblongata.

Ventricle puncture, introduced by Bergmann and Neisser²⁴, is obviously a last resort. The needle must of necessity travel from an infected area and injury to the brain blood vessels is likely.

Lavage of the cisterns is also in the nature of a last resort.

Laminectomy, once performed, is now obsolete.

When the cerebro-spinal fluid is draining without hindrance, nature may be assisted in her endeavour to flush out the cerebro-spinal system by the administration of extract of posterior lobe of pituitary, intramuscular injection of fresh choroid extract or injection intravenously of sterile distilled water.

The following was the treatment employed in the cases which recovered:-

- (1) Labyrinthitis (1 case): radical mastoid operation and translabyrinthine drainage.
- (2) Temporal Lobe abscess (4 cases): mastoid operation (Schwartz or radical, depending on whether the condition was acute or chronic), incision of the dura and evacuation of the contents of the abscess, drainage of the abscess cavity: daily lumbar punctures.
- (3) Sinus thrombosis and perisinus abscess (4 cases): Mastoid operation, removal of infection and frequent lumbar punctures.
- (4) Uncomplicated acute suppurative otitis media (2 cases): Schwartz operation and frequent lumbar punctures.

In five of the cases urotropin was either injected/

injected directly into the spinal canal or given per mouth (25 grains in 5 c.c. normal saline at body temperature into the spinal canal, or 5 grains thrice daily by mouth).

AFTER-TREATMENT.

Local. Hypertonic saline dressings or hypertonic saline and eusol dressings: make sure that cerebro-spinal fluid is draining: frequent lumbar punctures.

General. Intravenous therapy (Septicémine probably being the best drug to use).

Symptomatic.

CONCLUSIONS/

CONCLUSIONS.

1. That in acute diffuse purulent meningitis we have to deal with a very fatal disease.
2. There are two types of infection, one, the fulminating or fatal, the other a less virulent but often fatal type. The recoveries fall into the latter group.
3. Early diagnosis and treatment are essential.
4. The most successful line of treatment lies in complete eradication of the primary focus of infection, local drainage, frequent lumbar punctures and intravenous therapy.
5. In labyrinthine cases of meningitis, very early diagnosis is imperative as the spread of the meningitis is rapid owing to its anatomical position, and translabyrinthine drainage of the infected cerebro-spinal fluid is the line of attack par excellence.
6. When the drainage is free, natural lavage should be encouraged by therapeutic measures.
7. The meningitis may be masked by the more prominent symptoms of the infecting process and, inversely, meningitis may simulate almost any intracranial complication of suppurative otitis media.
8. Lumbar puncture is the surest guide to diagnosis and is a most useful adjunct to treatment.
9. In every case operative measures should be tried, whatever the state of the patient: inactivity means certain death.

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